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AUTHOR Fisher, Cynthia
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ABSTRACT

This study examined children's acquisition of language by means of correlating spoken words and observed objects and actions. The common sense view of word learning via observation applies easily to learning nouns for objects, but becomes problematic in the process of learning verbs. When they encounter novel verbs applied to observed situations, children are able to infer meaning using cues from word order and may be able to infer meaning using cues based on the transitivity of the verb and on the preposition that is used with the verb. In two experiments, 3- and 5-year-old children were shown videos of novel agent-patient and donor-recipient actions, along with descriptive sentences that contained transitive and intransitive nonsense verbs, and nonsense verbs with the prepositions "from" and "to." Then the children were asked to identify the agents of the actions. Found that, for agent-patient events described by sentences with transitive verbs, children were able to identify the agent almost all the time, but for agent-patient events described by sentences with intransitive verbs, children were able to identify the agent only about half the time. (ME)

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ED 369 497

Structural limits on verb mapping[1]

Cynthia Fisher

University of Illinois

What aspects of the word-learning context might children use to fix on the intended meaning of a new word? The common-sense conception of word-learning relies heavily on extra-linguistic cues: The child hears an unknown word, and simply inspects the scene in view to see what the speaker must mean by it. In this way "rabbit" comes to refer to rabbits just because it is typically uttered when rabbits are present. There are of course deep logical problems with this procedure, as has long been noted (e.g., Quine, 1960; Markman, 1989) — Meaning is in the eye of the beholder, not in the world, and therefore cannot be deductively determined from observations of the world.

In principle, the logic of the inductive problem is the same for nouns and for verbs: Observations of the world always offer up a multiplicity of interpretive possibilities. In practice, however, verbs seem to pose the word-mapping problem in a particularly intractable form. One of the most robust findings in early language use is the preponderance of nouns among children's first words (e.g., Au, Dapretto, & Song, 1993; Brown, 1973; Gentner, 1978, 1982). Why might it be so difficult to recover verb meanings from the extra-linguistic context? Gentner (1978, 1982) has suggested that the problem stems from differences in the typical meanings of nouns and verbs. While concrete nouns name objects in the world, even the most concrete verbs refer to relations among world entities. This difference has consequences for the kind of information needed to accurately fix on the meanings of verbs. Relations among objects, as expressed by languages, do not seem to follow in any simple way from basic human perceptual or conceptual capacities.

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[1]A longer version of this paper is currently under review. Address correspondence to Cynthia Fisher, Department of Psychology, University of Illinois, Champaign, IL 61820. (e-mail address: cfisher@s.psych.uiuc.edu)

One striking piece of evidence for the indeterminacy of verb concepts is that languages vary considerably in how the verb lexicon is organized, and what types of relational information are typically encoded by verbs (e.g., Choi & Bowerman, 1991; Pinker, 1989; Talmy, 1985). There is also considerable within-language variation in what stance particular verbs take on a given world event. Consider a child who witnesses her mother feeding an infant sibling. She might observe the speaker pointing at the feeding scene, the actions of the mother, the actions of the baby, various states and properties of the mother and the baby, and a vast array of relevant aspects of the scene in view. The child is free to represent this scene in any number of ways, several of which are lexicalized in English.

(1) Mother is feeding the baby.

(2) The baby is eating.

(3) Mother is giving food to the baby.

(4) The baby is getting food from Mother.

Feed and eat describe, not different events, but rather different views of the same event. Thus, though they have different meanings, they will virtually always be acceptable in the same world contexts. Similarly, give and get describe the same class of events — one cannot ordinarily claim to be giving if no one receives anything. Even repeated observations of scenes labeled with one of these verbs will not tell the learner which perspective — feeding as opposed to eating, or giving as opposed to getting — on the same class of events is intended by the speaker. Verb meanings, in principle and in practice, are underdetermined by observational evidence.

If verb meanings aren't in the world, where are they? Linguistic cues

The language itself can provide an additional source of information to solve the learner's predicament: Each time a child hears a new verb, she can not only observe what is going on in the world, but also may take note of the sentence in which the verb appears. Returning to the feeding/eating example, notice that feed expresses the cause of the event (the mother spoons food into the baby's mouth) and its result (the baby consumes the food), while eat omits the cause, expressing only the result. This semantic difference between the two verbs is transparently

expressed in their respective sentence contexts. Feed occurs with two noun phrases (NPs), the causal agent and the one who eats (as in (1)), while eat can occur intransitively (as in (2)), specifying only the eater. The aspect of a verb's meaning that is reflected in this way in sentence structures is its argument structure, specifying how many participants (and thus how many NPs) are required to play out the action described by the verb, and what roles they must play.

Evidence for syntactic constraints on verb mapping

Several studies have demonstrated that children are sensitive to the semantic consequences of sentence frames (e.g., Fisher, in press; Fisher, Gleitman & Gleitman, 1991; Fisher, Hall, Rakowitz & Gleitman, in press; Gleitman, 1990; Gleitman, Gleitman, Landau & Wanner, 1988; Landau & Gleitman, 1985; Naigles, 1990; Naigles, Gleitman, & Gleitman, in press). Fisher et al. (in press) found effects of a variety of different sentence contexts. For example, preschoolers observed a rabbit feeding an elephant, who ate. A nonsense verb was used to describe this scene, presented in one of two different sentence contexts, as shown in (5). Children showed strong effects of sentence context in their interpretations of such nonsense words. Subjects who heard the transitive sentence (5a) tended to define the nonsense word as something like feeding, while those who heard the intransitive sentence (5b) tended to paraphrase the new word as eating.

(5) (a) The bunny is nading the elephant. (feeding)

(b) The elephant is dacking. (eating)

(6) (a) The skunk is pilking the bunny. (chasing)

(b) The bunny is ziking the skunk. (fleeing)

(7) (a) The bunny is blicking the ball to the elephant. (giving)

(b) The elephant is nading the ball from the bunny. (getting)

Such findings show that children base their comprehension of a novel verb on their comprehension of the sentence that contains it. They have left unexamined, however, what aspects of the sentence context affect the learner's conjectures, and thus how the child makes use of syntactic cues to verb meaning. The example sentences shown in (5-7) provide several types

of grammatical cues that could be informative. First, each sentence contains familiar noun phrases that occur in a particular order. In example (6), constituent order makes the difference between a context sentence that suggests chasing and one that suggests fleeing. Second, in example (5), the two sentences have a different number of noun phrase arguments: One is transitive and the other is intransitive. Third, in example (7), the two sentences differ in their choice of a function word: Each contains a different preposition. All of these surface properties of sentences are clearly related to the argument structures of the verbs they contain — They are the syntactic devices for specifying the number and type of participants in an event. Which of these properties of sentences might affect children's interpretations of novel verbs?

Word order as a cue to verb meaning

It is clear from previous findings that children can use word order to infer aspects of verb meaning: Fisher et al. (in press) found that reversing the order of NP's in transitive sentences used to describe a single scene, as in (6), changed children's conjectures about the meaning of the verb in the sentence (e.g., from chase to flee). In this case, the only difference between the two sentences is the identity of the subject and object NPs.

To account for the effects of constituent order on verb interpretation, I assume (along with many others, e.g., Gleitman, 1990; Grimshaw, 1981, 1990; Gropen et al., 1991; Pinker, 1984, 1989; Schlesinger, 1988) that children have some notion of the meanings of various grammatical roles. This could be described by the sample pair of linking rules in (8).

(8) Agent <=> Subject

Patient <=> Direct Object

Children seem to be able to apply the linking rules shown in (8) in reverse: Subjects are interpreted as agents, and direct objects as patients. Having established, through application of these linking rules, that a transitive sentence containing a novel verb describes whatever X (the subject) is doing to Y (the object), the child can assign relevant aspects of the scene to the meaning of the verb. This step, taking constituent order as an aid to verb learning, reduces the hypothesis space for the child considerably. Now, when a child hears a novel verb, her question

(for the world) is not "What's happening?" but "What is X doing to Y?" On this view, the sentence provides what can be seen as a cast list for the event described.

Number of arguments and preposition choice as cues to verb meaning

It is also possible that sentence structures alone, without information about who is who in the sentence, could provide children with constraints on verb meanings. At least in principle, children could infer something about the kind of relation described by a verb if they knew only how many arguments it had. For example, transitive verbs describe relationships between two participants, such as the agent-patient relation, while intransitive verbs do not — they must denote a state, activity, or property of one entity. Thus it is the subjects of transitive verbs which strongly tend to be causal agents, as in (9); intransitive structures, as in (10), do not support a causal interpretation. It might be that children could interpret one- and two-argument verbs differently, even without the direct role-assignment information provided by a particular ordering of familiar nouns.

(9) John moved the car.

(10) The car moved.

Similarly, it might be that children could construct different interpretations of verbs based on their occurrence with particular prepositions, as in to versus from in example (7). To marks the oblique argument as a goal, while from marks it as a source. This could clue the learner in to an intended emphasis on the giving or getting aspects of the same events.

The current studies: Isolating structural cues to verb meaning

Can children derive information about the meanings of verbs from sentence context without the aid of word order? This summary describes the results of two experiments that examine this question. In both studies, preschoolers were taught novel verbs to describe novel events. Sentence context was varied between subjects to test for effects of syntactic structure on verb interpretation. Noun phrase identity information was removed from the sentence contexts by using ambiguous pronouns (she and her, denoting female participants in the events). The intent of this manipulation was to isolate number of arguments (transitive versus intransitive

sentences in Experiment 1) and their marking by preposition (to versus from in Experiments 1 and 2) as possible structural cues to verb meaning, independent of the identity of those arguments. This makes it possible to determine whether children can draw semantic conclusions from sentence structures alone, without knowing who is doing what to whom in the sentence.

EXPERIMENT 1

Four videotaped scenes were shown to children aged 3 and 5. Each scene showed two female participants engaged in a novel motion event.

Number of argument items. Two events showed one person (the agent) moving another (the patient) in some novel way. The two sentence contexts for these items differ in the number of NP arguments specified: The transitive sentences mention both participants ("She's blicking her"), while the intransitive sentence includes only one ("She's blicking"). Since the participants are identified merely as "she" and "her," these sentence contexts provide only structural information about the verb, not direct clues as to the identify of the subject and object of the verb.

Preposition items. Two other items showed a ball being transferred from one participant to the other, with some novel manner of delivery (e.g., the ball appears to magically float above the giver's hand) and of receipt (e.g., the taker whisks the ball away with a green fishnet). The two sentence contexts for these two items both have the same number of NP arguments (three), but differ in the preposition that marks the third argument: to versus from: "She's blicking the ball to her" vs. "She's blicking the ball from her."

Can a transitive structure direct a child's attention to relational aspects of an unfamiliar scene? Similarly, can a sentence marking an oblique object with to rather than from direct a child to delivery rather than acceptance in a novel game? The subject's interpretation of each novel verb was assessed in a forced-choice task. Children were asked to point out which of the two participants in each event was the perpetrator of the action described by the verb (e.g., "Point to the one who's blicking the other one over there."). This task, which preschool children performed with ease, provided a simple way of assessing what aspect of each event was

considered to be relevant to the meaning of the verb. The question of interest was whether subjects who heard the new verb presented in different sentence contexts would take different aspects of the scene (that is, the actions of different participants) to be described by the verb.

Results

Children's responses showed clear effects of the structure of the introducing sentence. The response of interest was simply which figure the children pointed to in the forced-choice task. These choices reveal whose actions the child thought were described by the novel verb. The frequency of the two possible choices was compared across the introducing sentences to determine how children's hypotheses about the meanings of novel verbs were affected by linguistic context.

Agent/patient events. Preschoolers' judgments of whose activities were described by a novel verb were significantly affected by the number of arguments (two versus one) specified in the introducing sentence. Both 3- and 5-year-old children assumed that the subject of a transitive verb used to describe an agent/patient event had to be an agent, choosing the causal agent in the event virtually all the time. Given an intransitive verb to describe the same event, however, children picked the agent only about half the time — they were more willing to consider that a non-agent subject was permissible. Thus, even for young children, transitive verbs differ from intransitive verbs in their meanings. The structure of the sentence itself, without order information to signal the assignment of grammatical roles to participants, led preschoolers to conjecture different kinds of meanings for novel verbs.

Donor/recipient events. The findings for the giving/getting events in Experiment 1 revealed no clear effect of sentence context, however. While preschoolers tended to interpret the nonsense verbs differently in the context of to and from, this effect was not reliable. This suggests two possibilities: One obvious interpretation is simply that young children are not sensitive to the content of prepositions in interpreting verb meanings, at an age when they can use number of arguments as a cue to the type of relation labeled by a verb. Another possibility is

that children can profit from closed-class cues of this type in interpreting novel verbs, but the particular stimulus items used in Experiment 1 failed to reveal this effect.

All stimulus events used in this study were designed to be unfamiliar, and therefore unnamed in the children's current lexicons. However, an unexamined feature of the to/from events in particular was that they appeared to be magical as well as novel. For example, in one giving/getting event, the giver never actually touched the object she was delivering — the ball was suspended over her outstretched hand by means of a thread not visible in the videotape. A similar mechanism was used to create an unfamiliar manner of giving in the second donor/recipient event. While adults clearly inferred the existence of an unseen thread in these events, it is more than possible that at least some of the children did not.

EXPERIMENT 2

Experiment 2 was designed to eliminate this potential confounding property of the stimulus events, to determine whether preschoolers (again 3- and 5-year-olds) can use the meaning of prepositions (again to versus from) to constrain their hypotheses about the meaning of a novel verb. The same forced-choice method was used to examine children's sensitivity to the to/from distinction in interpreting novel verbs. A new set of 8 stimulus events was videotaped, each involving only causation by means of visible physical contact. These events were otherwise of the same type as the donor/recipient events in Experiment 1, depicting two female participants in a novel game involving the giving and taking of an object. Will a sentence marking an oblique object with to rather than from (as in 11) direct a child to delivery rather than acceptance in a novel game?

(11) She's blicking the ball to her.

She's blicking the ball from her.

Results

When the causal structure of the labeled events was made clear, both 3- and 5-year-olds' responses were influenced by the preposition contained in the introducing sentence. As in Experiment 1, the response of interest was simply which figure the children pointed to in the

forced-choice task — the giver or the taker. Preschoolers' judgments were strongly affected by the preposition used to mark the oblique argument. Children who heard the novel verbs in a To sentence overwhelmingly interpreted those verbs as describing what the giver was doing, while children who heard them in a From sentence were much less likely to do so. Even for young children, verbs differ in their meanings depending on the prepositions used to mark their arguments. This reveals a second way in which the grammatical properties of verbs, independently of the identity of the subject and object, can provide cues to the kind of relation described.

DISCUSSION

These two experiments provide new evidence for children's use of grammatical cues in the process of acquiring verb meanings. Previous studies (e.g., Fisher et al., in press; Naigles, 1990) have found that young word-learners take verbs in different sentences to have different meanings. The studies reported here began to ask what aspects of sentence structures could affect hypotheses about word meaning, by isolating number of arguments and marking by preposition as grammatical cues to meaning. The result of this manipulation was clear: Children can use both of these properties of sentences to constrain their hypotheses about verb meaning. That is, transitive and intransitive verbs used to describe the same world events do not mean the same thing; nor do to and from verbs.

These findings demand an interesting revision of the verb-mapping procedure that was sketched in the introduction. In previous studies, the linguistic contexts supplied to novel verbs specified the identity of the verbs' arguments. Applying the subject-agent linking rule in reverse, the child could assume that the subject of the sentence must be the agent of the event, and therefore interpret the verb as referring to the actions of that participant. Thus, knowing that Bill is the subject of the sentence Bill kicked John, the young child can pair the verb kick with its environmental contingencies guided by the useful hypothesis that kicking is whatever Bill just did relative to John. This learning procedure makes a great deal of intuitive sense, and its use,

and the existence of the linking rules themselves, are supported by a range of evidence (e.g., Fisher et al., in press; Naigles, 1990; Pinker, 1984, 1989).

This procedure, however, can not explain children's success in the current task. Here, the context sentences did not tell children who in these events was doing what to whom. Instead, the sentences only specified how many arguments were assigned to each verb (one, two, or three), or labeled an oblique argument with a particular preposition. Preschoolers nevertheless concluded that two-argument verbs had different meanings from one-argument verbs, and that to verbs and from verbs described different aspects of events. The structure of a sentence itself thus provided children with information about the possible meanings of verbs, in some way not mediated by the identity of the subject and object of the sentence.

Verb-mapping as analogical mapping

What could it mean to say that sentence structures provide information about verb meaning? In what follows I will briefly sketch a revised model of verb learning that accounts for this finding. The central claim will be that sentence structures possess an abstract, relational meaning of their own, which can be applied by analogy to a child's representation of an event or state of affairs in the world. The result of this process of analogical mapping is the selection, from a detailed representation of a world event, of just those aspects of the event which are most likely to be relevant to the meaning of the verb.

Syntax has meaning because meaning has syntax. It is a core assumption of cognitive psychology that our mental representations of world events have structure of some kind. These knowledge structures go by various names, including conceptual or lexical-conceptual structures (Grimshaw, 1990; Jackendoff, 1983, 1990; Pinker, 1984, 1989; Levin, 1991), scripts, frames, or schemata (e.g., Schank & Abelson, 1977; Piaget, 1952), and the language of thought (Fodor, 1979; Braine, 1992), and have, under these different names, a wealth of differing detail. They all share, however, a basic division between predicates and arguments, and thus between entities and their properties or the relations among them. Predicates and arguments are the stuff of logic and

formal semantics; it is difficult to conceive of any representational system that does not honor this basic distinction in some fashion.

For current purposes, the consequence of this is that a child who maps a sentence she hears onto a situation she observes is mapping one structure onto another. The sentence provides a structure expressing relations among words, and the child's conceptual representation constitutes a structure expressing relations among world entities. One possible view of the sentence-world mapping proposed in the syntax-aided view of word learning is that the child attempts to bring the relational structure given by the sentence into one-to-one correspondence with a conceptual representation of world events. This is an analogy in its classical sense, involving use of a relational structure in one domain (the base domain) to draw attention to matching structure in another domain (the target domain).

To take a familiar example, one might explain the structure of the atom by drawing an analogy to the workings of the solar system. To do so is to invite the hearer to attend to relations between electrons and their nuclei that mirror the relations between planets and their suns. This notion of mapping on the basis of similarity in relational structure, independently of the particular objects related, was considered the hallmark of analogical reasoning by Aristotle, and has defined recent structural theories of analogical mapping (e.g., Gentner, 1989).

The place of one-to-one mapping in a grammar

A view of the basic problem of language acquisition is shown in Figure 1 (adapted from Jackendoff's depiction of a grammar, 1990). The function of a grammar is of course to assign interpretations to sentences — to map a sentence structure onto a part of conceptual structure. To accomplish this mapping, the adult speaker can use the route shown in panel (a) of the figure, taking advantage of a wealth of knowledge about a particular language and about the syntax and semantics of particular lexical items. The role of the verb in this process is of particular importance: Each verb specifies both syntactic and semantic information about its arguments. For example, in the three transitive sentences shown in (12), the roles played by John and Bill differ. In versions (a) and (b), John and Bill are agent and patient, while sentence (c) has no

traditional agent — John experiences something about Bill rather than causing some effect on Bill. This assignment of grammatical and semantic roles is part of what we know about know. A verb can thus be seen as a lexicalized set of instructions for determining who is doing what (if anything) to whom in the speaker's intended view of the world.

(12) a. John kicked Bill.

b. John killed Bill.

c. John knew Bill.

It is just this language- and word-specific knowledge that the beginning word-learner lacks. The child's task in learning new verbs is therefore to arrive at a mapping between a syntactic structure and a conceptual/semantic structure without knowing the correspondence rules to start with — in particular, without having the instructions for sentence-interpretation provided by the verb. For the child to make any headway in this task, it must be that there is another route from syntactic to conceptual structures.

The typical solution to this problem has been to assume that, in some significant subset of cases, there will only be one possible interpretation for a sentence; thus some sentence/meaning pairs can be established holistically to serve as a data base for determining the correspondence rules (Wexler & Cullicover, 1980; Pinker, 1984, 1989). This is the central empirical claim of the semantic bootstrapping view of the acquisition of grammatical knowledge. Here and elsewhere, however, it has been argued that this claim is unlikely to be true, due to the logical difficulties with the relational meanings of verbs (e.g., Choi & Bowerman, 1991; Fisher et al., in press; Gleitman, 1990). Relational meanings are language-dependent in a very strong way. A bias to establish a one-to-one mapping between the objects and relations in a syntactic and a conceptual representation could provide a route by which linguistic structure itself could aid in assigning an interpretation to a sentence. This is the proposed lower route shown in panel (b) of Figure 1. The child will consider that a new verb taking X and Y as arguments describes the relationship between X and Y in the world. Just as the familiar solar-system analogy invites one to attend to certain relations among sub-atomic particles, a sentence structure can be taken as an

analogy inviting the listener to attend to a subset of the candidate relations in a conceptual representation of an event. In the current task, a transitive sentence should be mapped onto a two-argument relation in the event, while an intransitive sentence could be mapped onto a one-argument predicate. For donor/recipient events, the number of arguments cannot distinguish between giving and getting, but the preposition serves to label one of the relationships between arguments in the sentence, and thus can constrain how the child aligns the objects of sentence structure and conceptual structure.

In the ordinary process of interpreting a sentence, 3- and 5-year-olds already have access to considerable language-, construction-, and word-specific information — the correspondence rules of Figure 1 — which could guide them in mapping from syntactic to conceptual structures. The point of the current manipulation, however, was to make much of this knowledge unavailable to them in what nevertheless remains a quite natural comprehension task. In the normal case, knowledge of a particular verb's semantic and syntactic properties tells the hearer how to map grammatical positions in sentences onto entities in a conceptual structure — who is doing what to whom. In these experiments, however, nonsense verbs were used; this put the subjects in the uninformed position of word-learners, forcing them to fall back on more general-purpose mechanisms for interpreting sentences. Further, argument positions in the context sentences were filled with ambiguous pronouns. Thus the context sentences did not allow children to make use of more general grammatical knowledge, including the subject-first word order of English. By stripping away much of the lexical and grammatical information that would ordinarily guide the mapping process, the current task allowed a look at a default process in which children can get meaning directly from structure.

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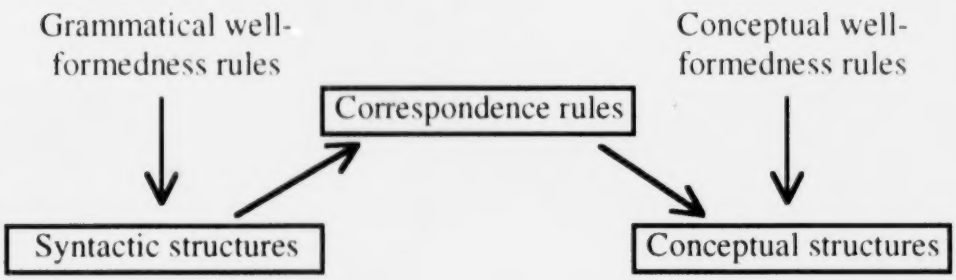
a)



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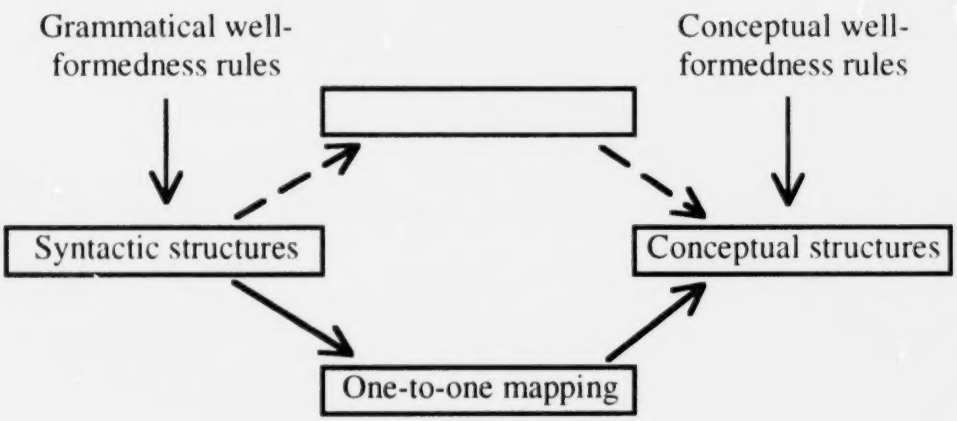

Figure 1: A model of (a) a mature grammar, adapted from Jackendoff (1990), and (b) the proposed initial state.